

Sari Edelstein

*Life Cycle*

# Nutrition

An Evidence-Based Approach

**SECOND EDITION**

*Life Cycle*  
**Nutrition**

An Evidence-Based Approach

**SECOND EDITION**

Editor

**Sari Edelstein, PhD, RD**

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To my wonderful colleagues at Simmons College:  
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*Life Cycle Nutrition: An Evidence-Based Approach, Second Edition* provides a unique learning experience, reference, and start for students learning about nutrition throughout the life cycle. It also provides a comprehensive reference for those of us already in practice. The book stands alone in its interwoven coverage of public health nutrition with subjects as diverse as media influences on eating, skipping breakfast, sociodemographic moderators of dietary intake, tobacco use and nutritional status, and clinical nutrition. It includes a wide array of diverse topics including parenteral nutrition and biochemical monitoring in neonates, inborn errors of metabolism, and cancer. Contemporary issues such as fruit juice consumption, nutritional needs of athletes, and dietary supplements as ergogenic aids are addressed across the life cycle as well as by using a multidisciplinary approach. This book gives students current information, helps them evaluate emerging information, and prepares them to uncover new information for the public, their clients, and themselves as they journey together through the life cycle.

The book is divided into two sections, the first of which focuses on prenatal to adolescent nutrition. The first chapter covers pregnancy and breastfeeding. Chapter 2 gives students insight into the growth and development of normal infants, along with some of their nutrition “issues” such as food safety and the effect of early diet on health outcomes. As outlined in Chapter 3, toddlers have different issues as they begin to explore their world and express food preferences; they start forming food habits and are influenced by caregiver behaviors. Chapter 4 emphasizes that school-aged children have different needs and are influenced by a wide variety of outside forces including role models as well as television and other media. Although caregivers have a large influence, school-aged children begin to make their own food choices and may be grazers or picky eaters. Adolescents, discussed in Chapter 4, are an understudied group with many nutrition issues; they, too, are influenced not only by media but also by their peers. Adolescents also make many of their own food choices and may

skip breakfast or consume fast food and added sugars, often in the form of sweetened beverages. Poor food choices contribute to increasing obesity and the appearance of nutrition-related chronic diseases formerly seen only in adults such as metabolic syndrome and type 2 diabetes. As students learn about the nutritional needs of infants, children, and adolescents, they learn how to help these groups improve their nutritional status.

Chapters 5 through 8 discuss the special nutrition considerations of infants, children, and adolescents. Eating disorders, failure to thrive, food allergies, and the nutrition needs of children with disabilities are covered in these chapters. Pediatric vegetarianism, childhood obesity, and the dietary needs of athletes are highlighted. Very specialized topics such as inborn errors of metabolism and nutrition support of the neonate are included.

Section 2 covers adult nutrition. Chapters 9 through 11 include information on chronic, nutrition-related diseases such as coronary heart disease, hypertension, diabetes, kidney disease, cancer, osteoporosis, HIV/AIDS, and obesity. Evidence analysis for evidence-based practice in these diseases is included as are prevention strategies. Chapter 11 is devoted to physical activity and weight management issues. Chapters 12 and 13 are dedicated to nutritional issues of the elderly. All topics ranging from special nutritional needs to nutritional problems, from activities of daily living to polypharmacy, and from risks of malnutrition to nutrition intervention are included in these chapters. Chapters 14 and 15 discuss professionalism and ethical issues, the final preparation for students to join nutritionists as colleagues.

### **New to This Edition**

The *Second Edition* of *Life Cycle Nutrition: An Evidence Based Approach* has been carefully updated to mirror current findings and features a wealth of new information in each chapter. Additionally, new case studies were added to each chapter, with answers available in the Instructor’s Manual.

Among the changes incorporated into this cutting-edge edition are the following:

#### Chapter 1

- Added information on epigenetics
- Expanded the section on lactation

#### Chapter 2

- Expanded the section on breast milk composition
- Incorporated WHO Guidelines
- Updated the American Academy of Pediatrics' section on Breastfeeding 2012 Recommendations
- Included information from the Feeding Infants and Toddlers Study (FITS)
- Added a new section on barriers to breastfeeding

#### Chapter 3

- Added the American Heart Association Guidelines for Young Children
- Utilized WHO Growth Charts
- Provided the National Institutes of Health approaches to pediatric obesity

#### Chapter 4

- Added a full range of Public Health Nutrition program updates
- Updated to Healthy People 2020 recommendations

#### Chapter 5

- Added a section on inborn errors of metabolism that covers these disorders:
  - 3-methylcrotonyl-coA carboxylase deficiency
  - methylmalonic acidemia
  - fatty acid oxidation disorders
  - pyruvate dehydrogenase deficiency

#### Chapter 6

- Revised the vitamin and mineral sections, including the following areas:
  - role of folate in Neural Tube Defects and Cardiac Problems
  - role of vitamin C in Respiratory Ailments
  - role for vitamin A in Child Health
  - role of phytates in plant foods in reducing zinc absorption
  - changes in the Dietary Reference Intakes (DRIs) for calcium and vitamin D
- Updated the section on autism spectrum disorders

#### Chapter 7

- Updated the section on vegetarian diets
  - Incorporated the Institute of Medicine's new Dietary Reference Intakes (DRIs) for calcium and vitamin D
- Added a section on the global rise in childhood obesity
- Updated the section on environmental influences on obese children
- Included dietary trends affecting obese children, including the following:
  - changes in the food environment
  - household food insecurity
  - prenatal influence
  - physical inactivity affecting obesity in children
  - opportunities to intervene and prevent
  - social programs

#### Chapter 8

- Fully revised the section on dietary guidelines for athletes
  - Added a new section on the role of vitamin D in athletic performance
  - Enhanced the information about the role of dietary supplements
- Updated the section on pediatric diabetes
  - Incorporated information from the American Diabetes Association's new "Standards of Medical Care in Diabetes"
  - Included information about insulin resistance in pediatric type 2 diabetes
- Revised the section on disordered eating
  - Revised the information on barriers to treatment

#### Chapter 9

- Revised to reflect the "Position of the American Dietetic Association: Weight Management"
- Incorporated the Institute of Medicine's new Dietary Reference Intakes (DRIs) for calcium and vitamin D

#### Chapter 10

- Revised the information about diseases of older Americans including prevalence, screening guidelines, and diagnosis-related conditions
- Added new material about health programs for elder adults
- Utilized the Healthy People 2020 recommendations

### Chapter 11

- Included data from new obesity evidence-based studies
- Utilized the Healthy People 2020 recommendations
- Incorporated new exercise guidelines for older adults
- Added material about obesity in diverse groups

### Chapter 12

- Added findings from The National Institute on Aging and the Administration on Aging
- Incorporated the Mini-Nutritional Assessment of Older Persons
- Updated the sections on macro- and micronutrient needs
- Added a discussion of the impact of socioeconomics on healthy aging
- Revised the demographics of aging

### Chapter 13

- Utilized current national health statistics
- Provided updated information from the National Institute of Deafness and Other Communication Disorders
- Included references to The Elderly Nutrition Program

### Chapter 14

- Utilized the Academy of Nutrition and Dietetics new position paper “Individualized Nutrition Approaches for Older Adults in Health Care Communities”
- Incorporated the American Health Care Association’s “The State of Long-Term Health Care Sector”

### Chapter 15

- Provided updates using the Academy of Nutrition and Dietetics 2008 position paper “Ethical and Legal Issues in Nutrition, Hydration and Feeding”
- Added the Academy of Nutrition and Dietetics “New Code of Ethics for the Profession of Dietetics and Process for Consideration of Ethical Issues”
- Utilized the American Society of Parenteral and Enteral Nutrition 2010 “A.S.P.E.N. Ethics Position Paper”

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# How to Use This Book

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This book has many exciting features that not only enhance its usefulness as a teaching tool but also expose future clinicians and scientists to the cutting edge of nutritional sciences.

**Evidence-Based Practice Sidebar.** This section contains articles where readers can transform the written word into a peer-reviewed study or clinical trial. I tell my students that I want to know their informed opinion. But how do they shape these opinions? Only by reading about evidence-based studies and medicine and by conducting studies themselves can students learn the importance of evidence-based practice. With the Evidence Analysis Library, the American Dietetic Association is a leader in presenting practitioners with the concept of evidence-based practice. This text complements this effort and enhances our students' familiarity with this important subject.

## Nitrates

Infant methemoglobinemia results in cyanosis in infants with few other clinical symptoms and is caused by nitrates in food or water that are converted to methemoglobin-producing nitrites before or after ingestion. The resulting compound, methemoglobin, cannot bind oxygen and results in hypoxemia. Absorbed nitrate that has not been converted to nitrite can be readily excreted in the urine without adverse effects. The greatest risk to infants comes from well water contaminated with nitrates (Greer, Shannon, the Committee of Nutrition, & the Committee on Environmental Health, 2005). It is estimated that 2 million families drink water from private wells that fail to meet federal drinking water standards for nitrate, and 40,000 infants younger than 6 months old live in homes that have nitrate-contaminated water supplies. Breastfed infants whose mothers consume water with high nitrate nitrogen concentrations are not at increased risk because nitrate concentration does not increase in human milk.

Nitrates also occur naturally in plants and may be concentrated in foods such as green beans, carrots, squash, spinach, and beets. Some commercially prepared infant foods are voluntarily monitored for nitrate content, and because of exceedingly high levels in spinach, this product is often labeled as not to be used for infants younger than 3 months of age. Concerns for home-prepared foods are unfounded because there is no nutritional indication for introduction of complementary foods before 6 months. The risk of methemoglobinemia decreases with age as the infant's gastric pH approaches lower levels typical of later childhood and fetal hemoglobin, which more readily oxidizes to methemoglobin, is replaced by adult hemoglobin after 3 months.

**Cultural Diversity Sidebar.** Cultural differences that involve nutrition and health differences and similarities among ethnic groups are highlighted.

This is a wonderful opportunity for students to learn more about what I call “diseases that discriminate”: obesity, cardiovascular disease, and diabetes are all most common in minority populations. Why? Are differences genetic, or are they related to life-style or to health care? What are the gaps in nutrition research in different groups? How do you work with people from cultures/ethnicities that are different from your own to improve their health or nutritional status? This feature will help students answer these questions, develop professionalism, and improve their practice.

## The Cultural Diversity of Poverty

Poverty is the most omnipresent of the social risk factors for failure to thrive. One study documented that 13% of patients with poor growth are homeless, which makes access to the medical care needed to prevent and correct malnutrition difficult (Frank & Zeisel, 1988). It is crucial in proper treatment of your patients that you consider their socioeconomic status in designing an individualized care plan.

**Critical Thinking Sidebar.** Found throughout the chapters, the points considered assist the reader in critical thinking concepts presented in different sections of the text. Perhaps the most important thing students can learn is to analyze and evaluate, examine and reason, reflect and decide. Why? So they can solve complex real-world problems, weigh evidence and make conclusions, learn to ask the right questions, and develop informed opinions to share with others.

## CRITICAL Thinking

Though controversial, flavored milk can be a good source of calcium and may increase compliance in young children. It may be helpful to choose lower fat milk and add flavoring with sugar-free syrups as a way to keep fat and added sugar intake low for toddlers older than age 2 years and still receive the benefits of calcium.

**Learning Points.** These items call out particularly important points.

● **Learning Point** Food-related behaviors are established early in life, and how and what an infant or toddler eats in the first years of life can influence later food choices.

**Case Studies.** These sections are provided to demonstrate chapter concepts. Case studies actively involve students in learning and simulate or represent actual problems they will face as professionals. Students can work alone or in groups to develop solutions as they would in the workplace. Thus, case studies help develop knowledge and skills of students in a wide variety of subjects and improve critical thinking, public speaking, and group interaction skills. Instructors can view the Case Study answers in the online Instructor’s Manual.

### Case Study 3

#### Infant Nutrition

Rachelle Lessen, MS, RD, IBCLC

Emory is a 6-week-old former full-term infant. Her mother is 30 years old, healthy, does not smoke, and this is her first baby. Emory has been exclusively breastfeeding since birth. She latched well from the beginning, and mom denies any difficulties or problems with sore nipples. Her output includes 10–11 wet diapers and 2 stools per day. Her mother reports that she breastfeeds more than 12 times per day and that her feedings are very long, typically more than 1 hour. Mom’s goal is to breastfeed her for more than 1 year.

Emory’s birth weight was 3.487 kg (75th percentile on the WHO growth chart). Her discharge weight from the hospital was 2.98 kg (10% below birth weight). At 1 week, she weighed 3.345 kg, and at 2 weeks she weighed 3.289 kg. Now at 6 weeks she weighs 3.52 kg (<2nd percentile on the WHO growth chart). She has gained 33 g since birth. Her head circumference and length are within normal.

#### Questions

1. What is the primary nutrition concern?
2. What is the most likely cause of the problem?
3. How would you improve her nutritional status while taking into consideration the mother’s breastfeeding goals?

**Issues to Debate.** These issues include withholding and withdrawing nutrition, the ethical implications of nutritional care, and right-to-die case law. It is critical that students learn the physiologic, moral, ethical, and legal aspects of these

emotionally charged issues. Debate and discussion with others help nutrition students understand these issues as they apply across the life span and how they will interact with other health professionals.

### Issues to Debate

1. Discuss obstacles to breastfeeding that women encounter and possible public health strategies to overcome these challenges.
2. What are the effects of early feeding on the development of obesity and what can be done to reduce the increasing rates of childhood obesity?
3. Infant formula manufacturers add DHA and AA to their products. This has greatly raised the cost to consumers (including the U.S. government, which is the largest purchaser of formula because of the WIC program), yet studies fail to show long-term benefit of these additions. Discuss the ethical implications of this practice.
4. What are some of the cultural aspects that affect the transitioning from an all-milk infant diet to a diet of family foods?

**Reader Objectives** guide students stepwise through the chapter.

#### Reader Objectives

After studying this chapter and reflecting on the contents, you should be able to

1. Describe normal infant nutrition in the first year of life.
2. Compare growth differences between breastfed and formula-fed infants.
3. Describe the impact of early diet on later development of obesity, diabetes, and food allergies.
4. Discuss adequate intake of key nutrients in the first year of life, including energy, protein, fatty acids, iron, zinc, and vitamin D.
5. Describe caregiver behaviors that can affect normal transitioning from an all-milk infant diet to a diet of family foods.
6. Compare and contrast actual complementary feeding patterns with recommended guidelines.

**Key Terms** throughout the chapters assist with new terminology and concepts.

#### Development of Growth Charts

The nutritional status of children is assessed by plotting height and weight on **growth charts** to determine adequacy of nutrient intake, particularly calories and protein. There is considerable evidence to show that growth rates differ for breastfed and formula-fed infants.

**growth charts** Graphs used to assess nutritional status of children by plotting height and weight and comparing these to reference data.

**Chapter Summaries** crystallize the most important elements of the chapters and help bring the chapter contents into perspective.

### Summary

In summary, the role for the RD in LTC settings is much more complex than it is in many other care settings. In LTC the dietitian is expected to be proficient in MNT and have expertise in the regulatory environment, food preparation, sanitation, dining, and survey and quality management. The provision of nutrition care in this setting also requires a proactive and system-oriented approach, where residents' quality of life is a primary consideration in every decision, and care should be provided in the most home-like manner possible. The potential for the RD to make a significant difference in the quality of life of residents and to be valued by the facility are limited only by the aspirations of the individual practitioner.

Following some chapters are **Special Sections**, which are designed to heighten curiosity and provide insight into particular issues.

## Special Section on the Social and Cultural Aspects of Breastfeeding

Yeemay Su Miller, MS, RD, Virginia L. Marchant-Schnee, BS,  
and Rachelle Lessen, MS, RD, IBCLC

### CHAPTER OUTLINE

<ul style="list-style-type: none"> <li>A Brief History of Breastfeeding</li> <li>Current Trends Affecting Breastfeeding</li> <li>Who Breastfeeds?</li> <li>Barriers to Breastfeeding</li> <li>Routine Maternity Care Practices</li> <li>Physiologic and Psychological Factors</li> </ul>	<ul style="list-style-type: none"> <li>Social Support and Acculturation</li> <li>Marketing of Breast Milk Substitutes</li> <li>Returning to Work</li> <li>Legislation: Protecting a Woman's Right to Breastfeed</li> </ul>
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#### Reader Objectives

After studying this special section and reflecting on the contents, you should be able to

1. Describe who breastfeeds, and why some women do not breastfeed.
2. Compare breastfeeding legislation around the United States.

#### A Brief History of Breastfeeding

Deciding whether to breastfeed and for how long is not as simple as deciding which car to buy. Many complex social and cultural factors play interrelated roles in a woman's decision to breastfeed. Until the mid-eighteenth century, aristocratic families,

and later the urban middle class, employed wet nurses to feed their infants as the social norm until the age of weaning, usually at 2 years of age. The ability to hire a wet nurse was regarded as a status symbol, and the mothers who hired wet nurses could then carry out upper-class social obligations and civic duties. One could draw parallels

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For the instructor, the following resources have been provided:

- A **Test Bank** featuring more than 400 multiple choice, true/false, and essay questions
- An **Instructor's Manual** containing answers to the case studies featured in the text
- **PowerPoint Presentations** including more than 15 slides per chapter

For the student, each new copy of this book comes with an access code for the **Navigate Companion Website**, which includes the following features:

- A supplemental chapter on interpreting evidence-based research
- Web links
- An interactive Glossary
- Animated Flashcards
- Crossword puzzles
- And more





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SECTION

I

**Evidence-Based  
Nutrition in the Life  
Cycle: Prenatal to  
the Adolescent**



# CHAPTER

# 1

# Nutrition Requirements During Pregnancy

*Lisa S. Brown, PhD, RD*

## CHAPTER OUTLINE

### National Status Prior to Pregnancy

- The Fetal Origins Hypothesis
- Maternal Preconception Weight Status
- Preexisting Conditions
- Public Health Campaigns to Improve Preconception Nutritional Status
- General Health and Nutrition Recommendations for Women Preconception

### Nutrient Needs During Pregnancy

- Total Energy
- Protein
- Lipids and Fats
- Calcium
- B Vitamins
- Iron
- Magnesium
- Zinc
- Iodine

### Fetal Development

- The Embryonic Phase
- The Fetal Phase
- Critical Periods of Nutrient Intake During Embryonic and Fetal Development

### Common Problems Associated with Pregnancy

- Nausea and Vomiting of Pregnancy and Food Aversions and Cravings
- Reflux
- Pica
- Preeclampsia
- Gestational Diabetes

### The Interaction of Lifestyle and Pregnancy

- Physical Activity, Safety, and Energy Needs
- Food Safety
- Alcohol
- Illegal Drug Use
- Cigarette Smoking
- Caffeine

Case Study 1: Nutrition Prior to Pregnancy by Lisa Brown, PhD, RD

Case Study 2: Gestational Diabetes by Lisa Brown, PhD, RD

Case Study 3: Weight Gain During Pregnancy by Lisa Brown, PhD, RD

Case Study 4: Vegetarian Pregnancy by Lisa Brown, PhD, RD

## Reader Objectives

After studying this chapter and reflecting on the contents, you should be able to

1. Describe some of the preexisting conditions that can occur in pregnancy.
2. Discuss the differences in the nutritional needs of pregnancy as compared to the nonpregnant woman.
3. Define problems commonly associated with pregnancy.
4. Relate the impact of lifestyle behaviors on fetal development.

What a woman eats when she is pregnant can have profound and lasting effects on her child's health. The expression "you are what you eat" applies, but in this case, it is this: "You are what your mother eats." During the prenatal period, the fetus has the enormous task of evolving in only 9 short months from a single-celled, fertilized egg to a human infant. To accomplish this, the fetus must have all of the necessary resources available in the proper quantities and at the exact times they are needed. Despite the daunting nature of the task, mothers have been producing healthy infants for thousands of years, demonstrating the amazing adaptability of both the mother and her child. The capacity of the mother's body to create the necessary conditions for fetal growth is one of the great miracles of life. There are limits, however, and the health of the child may suffer in obvious and not so obvious ways if certain thresholds for nutrients are not met.

Although a pregnant body has an amazing ability to compensate for nutrient deficiencies and excesses, a woman cannot provide essential nutrients for her child if she herself is deficient in them. Many factors influence a mother's nutritional status during her pregnancy. The mother's own health before conception, her health during pregnancy, her lifestyle choices, and environmental exposures can all change what and how much she eats and limit precious nutrients available for the growing fetus.

It is important that knowledgeable healthcare providers are available to support the mother-to-be with strategies to help her achieve the most balanced diet possible, thus ensuring the health of both mother and child. This chapter examines normal prenatal nutritional requirements and common factors that may compromise the mother's ability to provide ideal nutrition for her growing fetus.

## Nutritional Status Prior to Pregnancy

The period when a woman is pregnant is often looked at in isolation and is not put in a larger context of the mother's overall health. Although this has been the traditional approach to pregnancy, there is a growing movement to look at human nutrition using the life course approach, which is promoted by the World Health Organization. Using the life course approach, the mother is followed from her own conception through death, and factors that have influenced her health since she herself was in utero are considered when assessing risk of developing chronic diseases for both the mother and her offspring (Darnton-Hill, Nishida, & James, 2004).

### The Fetal Origins Hypothesis

The mother's health before and during pregnancy may be affected by genetics, as well as malnutrition, acute and chronic disease, exposure to environmental toxins, and a number of other factors. The fetal origins hypothesis proposes that certain genes in the fetus may or may not be "turned on" depending on the environment to which the mother is exposed while pregnant (Hampton, 2004). For example, if a mother is exposed to severe food restriction during pregnancy, as was the case in the Dutch Famine during World War II, her developing fetus will adapt genetically to thrive in an environment of severe energy restriction. The child's genetic programming will be sensitized to store fat more efficiently compared with those not exposed to famine in utero. If the environmental conditions the child is born into do not match the famine conditions, the child will accumulate fat more quickly than desired and be at higher risk of obesity, diabetes, and cardiovascular disease. Findings from the Dutch Famine and other cohorts support the

fetal origins hypothesis, and research is ongoing to confirm the process by which it works (Roseboom, de Rooij, & Painter, 2006; Thompson, 2007).

More recently research has focused on the role of epigenetic changes as the mechanism that mediates gene expression in the fetus (Langley-Evans, 2013). *Epigenetics* refers to the control “switches” that determine gene expression and can vary even if the DNA sequence itself does not change. Although human DNA changes slowly, it is believed that we adapt relatively quickly to our environment through the process of epigenetic gene activation and deactivation. Humans are born with many genes that are never activated. The prenatal and early childhood environment interacts with an individual’s genetic code to help select which genes will be useful in those specific environmental conditions (Godfrey, Lillycrop, Burdge, Gluckman, & Hanson, 2013).

In the World Health Organization life course approach to disease prevention, the passing of increased risk for chronic disease from mother to child based on prenatal environmental exposures is known as the intergenerational effect. The intergenerational effect is thought to be one reason behind the clustering of chronic disease risk factors in families of lower socioeconomic status. Women in lower socioeconomic classes are more likely to be exposed to extreme environmental conditions and have substandard health care, exacerbating problems. Interventions should seek to maximize the mother’s health before and during pregnancy to improve the short- and long-term health of her children. There is also growing evidence that intervention in the first years of the child’s life may affect long-term risk through modifying epigenetic programming (Lapillonne & Griffin, 2013).

### Maternal Preconception Weight Status

Many aspects of the mother’s health and lifestyle before pregnancy have been shown to affect her subsequent pregnancies with potential to influence the health of her children, but one area of particular concern is the mother’s weight before pregnancy. The dramatic increase of overweight and obesity in women in the United States has forced many healthcare providers to focus their counseling on weight management before and during pregnancy. Preconception obesity is associated with a substantial increase in risk for pregnancy complications, such as gestational diabetes and preeclampsia, as well as a significant increase in birth defects

(Chu et al., 2007; Hauger, Gibbons, Vik, & Belizán, 2008; Stothard, Tennant, Bell, & Rankin, 2009).

Both maternal obesity (BMI  $\geq$  30) and maternal overweight status (BMI = 25 to 29.9) have been shown to increase the risk of birth defects. One study from the Centers for Disease Control and Prevention found that babies born to mothers who were overweight at the time of conception had a higher risk for birth defects than those born to normal-weight women, including twice the risk of having babies with heart abnormalities. Mothers who were obese prior to conception were more than three times as likely to deliver babies with spina bifida or the abdominal malformation omphalocele (Watkins, Rasmussen, Honein, Botto, & Moore, 2003). A 2009 meta-analysis and systematic review found that compared to normal-weight women obese women had significantly high odds of giving birth to a baby with a neural tube defect, cardiovascular defects, hydrocephaly, and several other relatively common birth defects (Stothard et al., 2009).

A mother who is underweight prior to becoming pregnant also puts her baby at higher risk for complications, mainly because of the association between underweight status and malnutrition (Ehrenberg, Dierker, Milluzzi, & Mercer, 2003). As discussed earlier, maternal malnutrition during pregnancy may influence fetal programming, priming the child to be more susceptible to heart disease, diabetes, and high blood pressure later in life. Malnutrition may be caused by illness, food insecurity, or other factors, and both the malnutrition and the underlying cause need to be addressed to maximize positive outcomes for both mother and baby.

Regardless of nutritional status, a BMI of less than 18.5 has been associated with a higher risk of preterm delivery (Hauger et al., 2008). Underweight women should be carefully monitored to ensure that they are meeting their nutritional needs during pregnancy, and weight gain goals should be emphasized. Supplements may need to be customized to ensure that the mother-to-be meets her nutritional requirements. Referrals to social service programs to help the mother obtain food, health insurance, and housing assistance may be necessary if malnutrition is caused by food insecurity.

In some cases, underweight status before pregnancy and/or failure to gain appropriate weight during pregnancy may be a sign of either a pre-existing eating disorder or one that has developed

during pregnancy. “Pregorexia” is a recently coined term used to describe the practice of overly restricting energy intake and/or overexercising during pregnancy to minimize weight gain. The pregorexic mother disregards prenatal health guidelines in an effort to control her weight, with potentially dangerous short- and long-term effects for her baby. In addition to placing her baby at risk for poor growth and vitamin deficiencies, one study found that women with eating disorders were significantly more likely than those without to be at risk for fetal growth restriction, preterm labor, anemia, genitourinary tract infections, and labor induction (Bansil et al., 2008).

### Preexisting Conditions

In some cases, the mother may have a preexisting medical condition that may jeopardize the fetus’s health long before the child is born. Mothers with multiple sclerosis, type 1 diabetes, and other serious health conditions can have healthy, successful pregnancies, but they need to be carefully monitored by specialists as well as by a health-care team that is typically led by the obstetrician/gynecologist.

### Public Health Campaigns to Improve Preconception Nutritional Status

Ideally, most women will plan ahead and begin to adopt healthful behaviors compatible with a healthy pregnancy long before they are necessary. In reality, the majority of pregnancies are not planned, and thus, healthcare providers need to take every opportunity to encourage women to adopt healthful practices that will support a healthy pregnancy.

A few social marketing campaigns have been mounted over the years. They were designed to educate women of childbearing age on behaviors related to positive pregnancy outcomes, thus maximizing the health of their children if pregnancy occurs. One example is the March of Dimes campaign to encourage supplementation with folic acid for all women of childbearing age. The campaign had limited success, and many concluded that public health messages urging women to take folic acid supplements were ultimately far less effective in bringing about the kind of changes observed after fortification of the food supply with folic acid (Bower, Miller, Payne, & Serna, 2005). The March of Dimes discontinued this campaign shortly after and is currently focusing its education

and prevention efforts more broadly on reducing behaviors in women associated with premature birth.

### General Health and Nutrition Recommendations for Women Preconception

Preconception planning for all women should include advice to begin prenatal multivitamin/mineral supplements even before conception to build stores of valuable nutrients. In addition to a standard prenatal supplement, most women could likely benefit from taking fish oil to build stores of essential fatty acids before becoming pregnant.

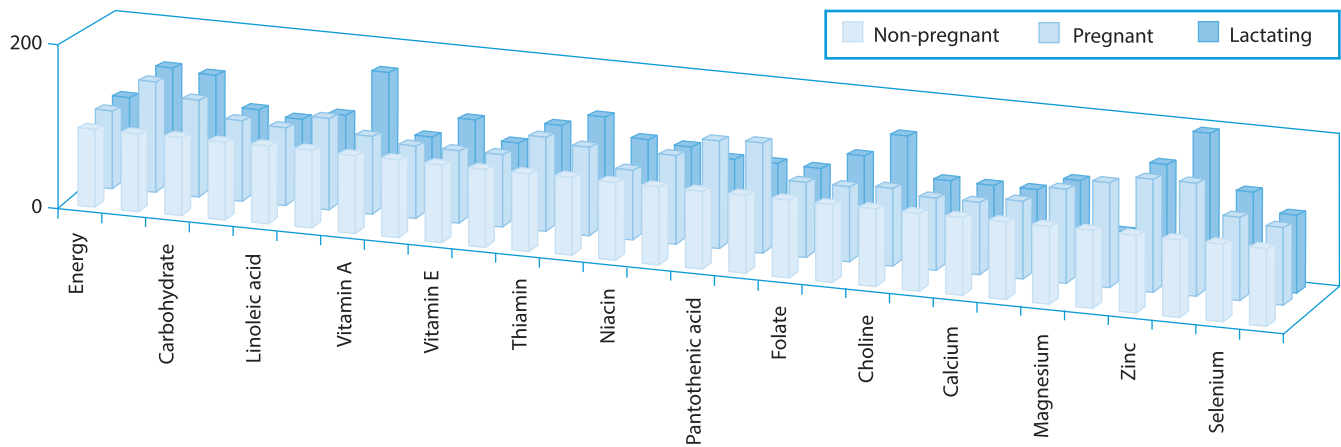
Lifestyle interventions should include advising women to stop smoking before they become pregnant. Alcohol and caffeine consumption should be moderated prior to conception, and alcohol should be discontinued altogether if a woman suspects that she is pregnant.

Other good practices to prepare for a healthy pregnancy include evaluating the safety of all medications the mother takes, whether prescription or over-the-counter, to determine whether they are safe to take during pregnancy. Alternate medications that are determined to be safe during pregnancy should be identified, and women should work with their doctors to switch over in the case of prescription medications.

A woman who needs to lose weight prior to conception should be very careful not to overrestrict micronutrients to a point that she becomes deficient. She should be careful not to compromise the health of the fetus when she does become pregnant by following a strict diet plan before becoming pregnant. The focus of preconception weight loss should be on cutting empty-calorie foods and increasing low-calorie, nutrient-dense foods such as fruits and vegetables, whole grains, and low-fat meats and dairy. Increasing exercise may also help the woman lose weight prior to becoming pregnant and have benefits after she becomes pregnant in helping her cope with some of the unpleasant side effects associated with pregnancy.

### Nutrient Needs During Pregnancy

The need for most nutrients is increased during pregnancy to meet the high demands of both the growing fetus and the mother who herself goes through a period of growth to carry the child and prepare for lactation. In this section, we discuss



**FIGURE 1.1** Compared nutrient needs

the general need for increased macronutrients and micronutrients (see [Figure 1.1](#)).

### Total Energy

It often is said that a pregnant woman is “eating for two.” Although this is technically correct, expectant mothers often overestimate their need for additional calories, especially early in the pregnancy. For most women, the extra energy needs are easily met by adding a small snack or two during the day. Eating smaller amounts of food more frequently throughout the day also has the benefit of helping with some of the uncomfortable side effects of pregnancy, including nausea and heartburn. The focus should be on increasing the consumption of nutrient-dense foods and minimizing empty-calorie foods that may provide the extra energy needed but do not provide micronutrients that are needed in much higher amounts compared with increased caloric needs.

Before 2002, the advice for pregnant women was to increase their energy intake by approximately 300 calories per day in the second and third trimesters (National Academy of Sciences Institute of Medicine, 1990). In 2002, the Institute of Medicine (IOM) revised the Dietary Reference Intake (DRI) for energy intake during pregnancy. The new recommendation is higher in total calories and more specific in how increased calorie needs should be distributed over the three trimesters of pregnancy. The new recommendation advises no additional calories for the first trimester, adds 340 kilocalories (kcal) for the second trimester, and 452 kcal for the third trimester (Panel on Macronutrients, Institute of Medicine, 2002).

In a comprehensive study released in 2004, Butte, Wong, Treuth, Ellis, and Smith (2004) reported that additional energy needs not only differ by trimester but also should be tailored based on the mother’s preconception BMI. Butte and colleagues stated that the additional energy needs during pregnancy by trimester consisted of an additional 150 kcal/day for the underweight woman in the first trimester. In the second trimester, the underweight woman would require a 200 kcal/day increase in usual intake, whereas the normal-weight woman would require 350 kcal/day extra, and the overweight/obese would require 450 kcal/day extra energy. The third trimester would require 300 kcal/day extra for the underweight woman, 500 kcal/day for the normal-weight woman, and 350 kcal/day extra for the overweight/obese woman.

Although the Butt et al. study and the DRI recommendations provide a general guideline for caloric intake during pregnancy, the most accurate way to monitor whether the mother is consuming appropriate energy intake is to monitor her weight gain (see [Table 1.1](#) and [Table 1.2](#)). A variety of factors can alter the woman’s need for additional calories, with level of physical activity being the most influential, as it is for nonpregnant women. Physical activity during pregnancy is discussed later in this chapter.

### Protein

Healthy fetal development depends on the availability of adequate protein, which provides the basic building blocks necessary for formation of enzymes, antibodies, muscle, and collagen, which are used as the framework for skin, bones, blood vessels, and



**TABLE 1.1****2009 Institute of Medicine Guidelines for Prenatal Weight Gain**

Weight Category	Recommended Weight Gain
Underweight: BMI less than 18.5	28–40 pounds
Normal weight: BMI 18.5–24.9	25–35 pounds
Overweight: BMI 25.0–29.9	15–25 pounds
Obese: BMI greater than 30.0	11–20 pounds
Twins	35–45 pounds

Modified from Institute of Medicine (2009). *Weight Gain During Pregnancy: Reexamining the Guidelines*. National Academies Press; Washington, DC.

**TABLE 1.2****Average Weight Distribution of Weight Gained During Pregnancy**

Weight	Distribution
7.5 pounds	Average baby's weight
7 pounds	Extra stored protein, fat, and other nutrients
4 pounds	Extra blood
4 pounds	Other additional body fluids
2 pounds	Breast enlargement
2 pounds	Uterine enlargement
2 pounds	Amniotic fluid
1.5 pounds	Placenta

other body tissue. During pregnancy, the mother must consume adequate protein to meet the needs of her growing fetus, in addition to meeting her own increased needs as she physically grows in size to carry her baby. To accommodate the high demand, the mother's body adapts during pregnancy to conserve protein. Hormones signal the body that she is in a period of anabolism, which causes her body to retain nitrogen for protein synthesis.

The Reference Daily Intake (RDI) for protein for a nonpregnant woman is 0.8 grams per kilogram (g/kg), which comes to approximately 54 g per day for a 150-lb woman. The 2002 RDI for pregnant women recommends 1.1 g/kg of body weight, or an additional 25 g per day to meet the needs of pregnancy. According to the National Health and Nutrition Examination Survey (NHANES), the average daily protein intake for a woman

aged 20 to 39 years in the United States is 74 g, and thus, protein needs should easily be met by most American women, even during times of elevated need such as pregnancy (Centers for Disease Control and Prevention [CDC], 2004).

Despite the generally high level of protein intake within the United States, several special populations should be carefully monitored for adequate protein intake and quality during pregnancy: vegetarians, vegans, low-income women experiencing food insecurity, and woman experiencing severe nausea and vomiting.

When evaluating the mother's protein status, several factors should be taken into account. The mother may be consuming an adequate number of calories but taking in insufficient protein, leading to a protein deficiency. Conversely, the mother may consume adequate protein but may still have a protein deficiency if her calorie intake is too low. To meet the increased energy needs of pregnancy, some amino acids may be used for energy, leading to a protein deficiency. Finally, the quality of the mother's protein intake should be accounted for. If the mother does not consume high-quality sources of protein, meaning sources that include all essential amino acids such as meat, eggs, poultry, fish, and dairy, she should be encouraged to consume a variety of plant-based foods to ensure that all essential amino acids are available to the fetus.

A woman who chooses a vegan diet eats no dairy products, meat, fish, or poultry, placing her at higher risk for protein deficiency both before and during pregnancy. She must consume all essential amino acids from plant sources to create the protein necessary for her fetus's growth. Although it is possible for a vegan mother to have a healthy pregnancy, careful planning and monitoring to ensure that she is meeting her increased protein needs is essential. Lacto-ovo vegetarians who do not eat red meat, poultry, or fish should also be screened for protein deficiency, although they are at a much lower level of risk because of consumption of high-quality protein in the form of milk, cheese, yogurt, and eggs.

Although vegetarianism and veganism place a woman at higher risk of protein deficiency because of limited sources of protein that may limit total protein intake, prenatal consumption of plant-based proteins including beans and nuts is associated with lower risk of gestational diabetes and lower fat mass in children into the teen years and should be encouraged in pregnant women

either in combination with animal protein intake or promoted as a good protein source for vegan women (Bao, Bowers, Tobias, Hu, & Zhang, 2013; Yin, Quinn, Dwyer, Ponsonby, & Jones, 2012).

Low-income women also are at high risk of protein deficiency during pregnancy because of potential issues with food insecurity. A woman who is food insecure may lack adequate resources to obtain protein-rich, nutrient-dense foods, which often cost more compared with less nutritious foods. It is important to help food-insecure women identify low-cost protein sources, such as canned tuna, beans, eggs, and limited amounts of meat. Woman experiencing food insecurity also should be referred to nutrition assistance programs such as WIC, the Supplemental Nutrition Assistance Program (SNAP), formerly known as food stamps, and local food pantries.

### Lipids and Fats

The mother-to-be must include enough fat in her diet to meet the needs of her growing baby. Lipids, including sterols, phospholipids, and triglycerides, which are primarily made up of fatty acids, are another basic building material of body tissue and integral to body functioning. Lipids are essential for the formation of cell membranes and hormones and are necessary for proper eye and brain development, especially during the prenatal period and into the first few years of the child's life (Innis & Friesen, 2008).

Fat is also a source of concentrated calories, which may be beneficial to woman at risk of energy malnutrition while pregnant. Women who are not at risk should avoid excess fat because it can easily lead to undesired weight gain; moderation is essential. There is no separate RDI for fat intake during pregnancy, and the recommendation remains 20% to 35% of total calories, the same as for the general population. Fat intake during pregnancy should emphasize sources that provide the essential fatty acids and choline, a component of phospholipids necessary for healthy brain function.

### Essential Fatty Acids

The essential fatty acids linoleic acid (omega-6) and linolenic acid (omega-3) are necessary for optimal formation of the brain and eyes and also play a key role in the body as precursors of hormone-like substances called eicosanoids. Eicosanoids are used to signal a number of local reactions within the human body necessary for basic functioning.

Reactions such as muscle relaxation and blood vessel constriction are signaled by eicosanoids. Immune functions such as the inflammatory response to injury and infection that signals initiation of fever, aggregation of antibodies, and pain are also controlled by eicosanoids (Connor, 2000).

Although omega-6 fatty acids are used to create proinflammatory eicosanoids, omega-3 fatty acids are used to create anti-inflammatory versions. When the body has sufficient access to both essential fatty acids, it is able to create balanced amounts of each type, allowing for optimal immune function. This balance is only possible when the two essential fatty acids are consumed through diet or supplements in adequate amounts. Although omega-6 fatty acids are plentiful in the American diet through meat and vegetable oils, omega-3 fatty acids are relatively deficient. This imbalance would theoretically lead to the ability to mount a proinflammatory response without an equal ability to slow and stop it. Omega-3 fatty acid deficiency has also been linked with lower IQ scores in infants and lower scores of visual acuity, as well as an increased risk of depression in adults; it is suspected to be one potential reason for an increased risk for chronic diseases with an inflammatory component such as cardiovascular disease (Bourre, 2007; Connor, 2000; Horrocks & Yeo, 1999).

The amount of these essential fatty acids available to the fetus is based on how much the mother eats. If a mother-to-be consumes a typical American diet, the fetal tissue will have a high concentration of omega-6. Omega-3 fatty acids are generally deficient in the standard American diet and consumed in a ratio of 1 to 10 with omega-6 fatty acids (Briefel & Johnson, 2004). This deficiency may be even more pronounced in pregnant women who avoid seafood, one of the richest sources of omega-3, because of fears of mercury contamination.

Supplementation with omega-3 fatty acids increases the availability to the fetus and should be recommended to every woman who is currently pregnant or is planning to become pregnant. The mother should be advised to continue to supplement with omega-3 fatty acids during lactation.

The revised 2002 RDI for essential fatty acids recommends an Adequate Intake (AI) of 13 g per day of omega-6 and 1.4 g per day of omega-3. It further states that the ratio of the two fatty acids should be no more than 5:1. Because of a lack of data, the AI for essential fatty acids likely does not represent ideal levels for each nutrient and